REMARKS

Applicants are amending their claims in order to further clarify the definition of various aspects of the present invention. Specifically, Applicants have amended claim 1 to recite that each of ℓ, m and n is 1 or more and less than 4, provided that ℓ+m+n is 3 or more. Note, for example, page 7, lines 12-15 of Applicants' specification. Claim 13 has been amended to properly set forth "ℓ".

Initially, it is respectfully requested that the present amendments be entered. Noting, for example, previously considered claim 13, it is respectfully submitted that the present amendments to claim 1, setting forth minimum levels for each of ℓ, m and n and for the sum of ℓ, m and n, do not raise any new issues, including any issue of new matter; and, moreover, materially limit issues remaining in connection with the above-identified application, and, at the very least, present the claims in better form for appeal. Noting additional arguments by the Examiner in the Office Action mailed May 1, 2007, it is respectfully submitted that the present amendments are clearly timely.

In view of the foregoing, it is respectfully submitted that Applicants have made the necessary showing under 37 CFR 1.116(b); and that, accordingly, entry of the present amendments is clearly proper.

Applicants respectfully submit that all of the claims presented for consideration by the Examiner patentably distinguish over the teachings of the prior art applied by the Examiner in rejecting claims in the Office Action mailed May 1, 2007, that is, the teachings of U.S. Patent No. 6,833,220 to Yokoyama, et al. (Yokoyama '220), Japanese Patent Document No. 2002-348323 to Yokoyama, et al., and International (PCT) Published Application No. WO 03/031453 to Yokoyama, et al., under the provisions of 35 USC 102 and 35 USC 103.

It is respectfully submitted that these references as applied by the Examiner would have neither taught nor would have suggested such a lithium secondary battery as in the present claims, including, inter alia, an electrolyte containing an ion conductive material and an electrolytic salt, and wherein the ion conductive material contains a boron-containing compound represented by the formula (1) in claim 1, with Z_1, Z_2 and Z_3 each representing an organic group having an acryloyl group or a methacryloyl group or a hydrocarbon group of 1-10 carbon atoms, with the proviso that one or two of Z_1, Z_2 and Z_3 are organic groups having an acryloyl group or a methacryloyl group, and with, inter alia, ℓ, m and n of the formula 1 each representing an average degree of polymerization of the oxyalkylene group and is one or more, and less than 4, provided that ℓ+m+n is 3 or more. See claim 1.

As will be shown further infra, it is respectfully submitted that the applied references disclose ion conductive materials wherein all of the moieties corresponding to Z_1, Z_2 and Z_3 represent an organic group having an acryloyl group or a methacryloyl group, or which can have a relatively large molecular weight, and would have neither disclosed nor would have suggested such battery including ion conductive material as in the present claims, containing a boron-containing compound represented by the formula (1) in claim 1, with one or two (i.e., not all three) of Z_1, Z_2 and Z_3 being organic groups having an acryloyl group or a methacryloyl group, and with ℓ, m and n as in present claim 1, and advantages thereof, as discussed infra.

Furthermore, it is respectfully submitted that these references would have neither taught nor would have suggested such a lithium secondary battery as in the present claims, having, inter alia, the electrolyte containing an ion conductive material and an electrolytic salt, and wherein the ion conductive material comprises a

polymerizable composition which contains boron-containing compounds respectively represented by the formula (2) and the formula (3), as in claim 3, and wherein p, q, r, α, β and γ of the formulas (2) and (3) each represent an average degree of polymerization of the oxyalkylene group and is more than 0 and less than 4, provided that each of the sum of p + q + r and the sum of α + β + γ is one or more. See claim 3.

In addition, it is respectfully submitted that these applied references would have neither taught nor would have suggested such lithium secondary battery as in the present claims, including the compounds of the formula (2) and of the formula (3) as in claim 3, and wherein these compounds are included in a molar ratio of the compound of formula (2) to the compound of the formula (3) of 0.1 - 9 (see claim 4); more specifically, 0.5 - 4 (see claim 20), even more specifically, 1 - 2.5 (see claim 21).

Furthermore, it is respectfully submitted that these applied references would have neither taught nor would have suggested such a lithium secondary battery as in the present claims, having features as discussed previously in connection with claims 1 and 3, and, moreover, wherein the electrolyte contains a polymer obtained by polymerizing the boron-containing compound of the formula (1) (see claim 2), or contains a polymer obtained by polymerizing the polymerizable composition recited in claim 3 (note claims 5 and 6); and/or the further definition of ℓ, m, n, p, q, r, α, β and γ, as in claims 13 and 19; and/or molecular weights of the compounds of the formulas (1), (2) and (3), as in claims 11, 14, 15 and 16; and/or number of carbon atoms in AO, as in claims 12 and 17; and/or wherein all of Z_4, Z_5, and Z_6 are organic groups having an acryloyl group or a methacryloyl group (see claim 18); and/or the

electrolytic salt included with the ion conductive material discussed previously, as in claims 7-10.

The present invention is directed to a lithium secondary battery. Recently, there have been proposed secondary batteries utilizing solid electrolytes, including organic polymers. Organic polymers are generally superior in processability and moldability as compared to other solid electrolytes, e.g., inorganic materials, and, as a result, it is expected that organic polymers will be useful in lithium secondary batteries.

However, a defect in previously proposed organic polymer electrolytes in such secondary batteries is an inferior ionic conductivity. The previously proposed polymer electrolytes have such poor ion conductivity that sufficient current density at the time of charging and discharging of batteries cannot be obtained, and such polymer electrolytes are not applicable for heavy current use. That is, previously proposed polymer electrolytes do not have a value of ionic conductivity (1mS/cm or higher at room temperature) which is required in practice for electrolytes of lithium secondary batteries. See the last full paragraph on page 2 of Applicants' specification. And previously proposed polymer electrolytes have inferior high rate discharge characteristics.

Against this background, Applicants provide an ion conductive material having satisfactory ionic conductivity and good high rate discharge characteristics, yet which can easily be made and has other effective properties for an ionic conductive material of a lithium secondary battery. Specifically, Applicants have found that by utilizing boron-containing compounds as in the present claims, having a relatively small number of oxyalkylene groups (that is, where ℓ, m and n each represent an average degree of polymerization of the oxyalkylene group and are each 1 or more,

and less than 4, preferably 1-3; or where p, q, r, α, β and γ each represent an average degree of polymerization of the oxyalkylene group and are each more than 0 and less than 4, with the sum of ℓ, m and n being 3 or more, and the sum of p, q and r, and α, β and γ, being 1 or more, and, moreover, in connection with formula (1) wherein only one or two of Z_1, Z_2 and Z_3 are organic groups having an acryloyl group or a methacryloyl group, objectives of the present invention are achieved, and, in particular, an electrolyte is provided having sufficient ionic conductivity, and good high rate discharge characteristics.

That is, the compound of the present invention, utilized as the ionic conductive material, contains boric acid ester and has a specific average degree of polymerization of the added polyoxyalkylene group. Such specific molecular structure of the present invention achieves good mobility of the molecule chain and high boron concentration at the same time, so that there are simultaneously achieved high ion conductivity, good initial charging capacity, long cycle performance and high rate discharging characteristics.

Moreover, the polymer electrolyte of the present invention can attain high ion conductivity without using a non-aqueous solvent such as a carbonate, and hence is also relatively safe.

In particular, attention is respectfully directed to Examples 1-30 in Table 2, on page 52 of Applicants' specification. From this Table, it can be seen that it is important that the average degree of polymerization of the oxyalkylene group be less than 4 and at least one, and that the terminal group (Z_1, Z_2 or Z_3) other than the acryloyl or methacryloyl groups be a hydrocarbon group of 1 to 10 carbon atoms.

Moreover, if the average degree of polymerization is relatively large, e.g., up to 600 as in claims of U.S. Patent No. 6,998,465, discussed infra, it is impossible to attain sufficient ion conductivity as well as initial discharge capacity, cycle performance and high rate discharge characteristics, as seen from Comparative Examples 1 and 2 in Table 2 on page 52 of the above-identified application.

That is, Comparative Example 1 of the above-identified application uses a polymer electrolyte containing a polymerizable boron-containing compound having an average degree of polymerization of oxyalkylene group of 8, while Comparative Example 2 uses a polymer electrolyte containing a polymerizable boron-containing compound having an average degree of polymerization of oxyalkylene group of 12, and boron-containing compound having an average degree of polymerization of oxyalkylene group of 8. The boron-containing compounds in these Examples are poor in ion conductivity, initial discharge capacity, cycle performance and high rate discharge characteristics.

It is respectfully submitted that this evidence of record, which must be considered in determining patentability of the presently claimed subject matter, establishes unexpectedly better results achieved by the present invention, as compared to the closest prior art.

While Applicants relied on the evidence in their specification, on pages 10-12, for example, of the Amendment submitted March 5, 2007, the Examiner did not address this evidence. Such failure to address evidence of record is clearly improper. See Manual of Patent Examining Procedure 716.01. It is respectfully submitted that upon review of the evidence of record, such evidence shows unexpectedly better results achieved by the present invention, and, correspondingly, patentability thereof.

Japanese Patent Document 2002-348323 discloses a polymerizable borate compound useful as a material for electrochemical devices such as a secondary battery, obtained by esterification of a polymerizable compound represented by formula (1) (that is, XO $(AO)_nH$, wherein X is an acryloyl group or methacryloyl group, AO is a two-four carbon oxyalkylene group and n = 1 - 100) with boric acid or boric acid anhydride.

No. WO 03/031453 discloses a process for producing a boric ester compound which comprises reacting a compound represented by the formula (1) (that is, $X-[O(AO)_n-H]_a$, X being a group independently selected among a residue of a compound having 1-6 hydroxy groups, acryloyl and methacryloyl) with a boron compound represented by the formula (2) $((RO)_3-B$, where R is C_{1-4} alkyl) to produce the boric ester compound. Also disclosed are polymer electrolytes containing the boric ester compound.

As seen in the foregoing, as well as from full reviews of each of the published Japanese patent document and International published application, it is respectfully submitted that these documents would have neither taught nor would have suggested the presently claimed invention, including average degree of polymerization of the oxyalkylene group, and advantages achieved due thereto, including, e.g., high ionic conductivity and high rate discharge characteristics.

In particular, note Examples 1-30 of the present application, the results of which are shown in Table 2 on page 52 of the specification. Results for Comparative Examples 1 and 2 are also shown in this Table 2. For evaluating high rate discharge characteristics, discharge characteristics are tested at high current density conditions. Polymer electrolytes conventionally used have low ionic conductivity and

hence are insufficient in high rate discharge characteristics, important properties for practical use.

In order to obtain all the advantages of the present invention including high rate discharge characteristics, it is important that the average polymerization degree of the oxyalkylene group be at least 1, and less than 4, which is neither disclosed nor suggested, nor is obtained, in No. 2002-348323 or No. WO 03/031453.

In contrast, the present invention, utilizing the ion conductive material as in the present claims, having the recited average degree of polymerization of the oxyalkylene groups, obtains all of sufficient initial discharge capacity, cycle life, high rate discharge characteristics and ionic conductivity. Neither of No. 2002-348323 or No. WO 03/031453 would have disclosed nor would have suggested the presently claimed invention, including specific material utilized as the ion conductive material of the electrolyte, and advantages achieved thereby.

U.S. Patent No. 6,833,220 discloses an electrolyte, for secondary batteries, which is a polymer electrolyte, the electrolyte including an ionic compound and an organic polymer compound, the organic polymer compound comprising a compound represented by the general formula (1) or (2) (see column 2 of the patent) or a polymerization product of a boric acid ester compound obtained by the esterification of the compound represented by the general formula (1) or (2) with boric acid or boric anhydride. Note, in particular, column 2, lines 21-38; and column 2, line 50 through column 3, line 8. See also the paragraph bridging columns 6 and 7 of this patent. The Examiner has also referred to column 34 of this patent, column 34 setting forth fully therein claims 2-7 and the first two lines of claim 8, the Examiner referring to a specific formula set forth in claim 4 thereof.

It is respectfully submitted that in No. 6,833,220, all of the boron compound molecules have polymerizable functional groups, so that crosslinking density of the resulting polymer compound becomes high and its elastic modulus is high. In contrast, note that R_1, R_2 and R_3 in claim 3 each represent a hydrocarbon group of 1-10 carbon atoms. That is, R_1, R_2 and R_3 are not polymerizable functional groups. Moreover, one of Z_1, Z_2 and Z_3 of claim 1 represents a hydrocarbon group of 1-10 carbon atoms, not a polymerizable functional group. It is respectfully submitted that No. 6,833,220 would have neither disclosed nor would have suggested the presently claimed invention, including, inter alia, the compound of the formula (3), or the compound of the formula (1) and advantages thereof.

Furthermore, note that No. 6,833,220 discloses that the compound can have as many as 600 oxyalkylene groups. It is respectfully submitted that the resulting polymer compound would have poor mobility, and, consequently, ionic conductivity of the polymer compound would be low. It is respectfully submitted that No. 6,833,220 would have neither taught nor would have suggested the degree of polymerization as in the present claims, and advantages thereof.

In summary, it is respectfully submitted that No. 6,833,220 does not disclose, nor would have suggested, the battery as in the present claims, including the ion conductive material having the degree of polymerization of the oxyalkylene group as in all the claims; or having the compound of formula (1) having one or two of Z_1, Z_2 and Z_3 with the acryloyl group of methacryloyl group (leaving one group, of Z_1, Z_2 and Z_3, of a hydrocarbon group of 1-10 carbon atoms); or having, the additional compound containing boron atom and without polymerizable functional groups as in the compound of formula (3) in the present claims, and advantages thereof.

Furthermore, note the molecular weight recited in, e.g., claims 11 and 14-16. Such relatively small molecular weight is indicative of a small number of AO groups. It is respectfully submitted that the teachings of the applied references would have neither taught nor would have suggested compounds represented by the formulas (1), (2) and (3) having the specified molecular weight, as the ion conductive material of the electrolyte of the lithium secondary battery of the present claims, and advantage thereof.

It is emphasized that in each of Japanese Patent Document No. 2002-348323, International (PCT) Application No. WO 03/031453, and Yokoyama '220, the terminal substituents of the ion conductive material has increased elasticity and are hardened with enhancement of the crosslinking density. Therefore, mobility of the polymer chain becomes poor, and ion conductivity of the ion conductive materials becomes low, so that batteries having high discharging characteristics cannot be obtained. In contrast, according to the present invention, having terminal moieties that are not functional groups (e.g., a hydrocarbon group of 1-10 carbon atoms), high discharging characteristics can be attained.

Applicants respectfully traverse the non-statutory obviousness-type double patenting rejection of claims 1 and 2, over claims 6, 9, 11 and 13 of U.S. Patent No. 6,998,465. As will be shown in the following, it is respectfully submitted that the subject matter of claims 6, 9, 11 and 13 of U.S. Patent No. 6,998,465 would have neither disclosed nor would have suggested the presently claimed subject matter, including, inter alia, values for ℓ, m and n, p, q, r, α, β and γ, as in the present claims, and advantages thereof.

Thus, No. 6,998,465 recites, in claims 6, 9, 11 and 13, a secondary battery using an electrolyte formed by a process as in a prior claim of No. 6,998,465.

Claims 6, 9, 11 and 13 of this patent are dependent ultimately on claim 1, reciting a process for producing a boric acid ester compound which includes esterifying a compound represented by the following formula (1): $X-[O(AO)_n-H]_a$, wherein, inter alia, AO represents an oxyalkylene group having 2-4 carbon atoms, and n is 1-600. Compare with ℓ, m and n of claim 1; and with p, q, r, α, β and γ of claim 3. Note that claims 1 and 2 select a range at a lower end of the range for "n", in claim 1 of No. 6,998,465.

As discussed previously, according to the present invention, high initial discharge capacity and high rate discharge characteristics are obtained, due to the average degree of polymerization of the oxyalkylene group being less than 4 and at least 1; and, moreover, the evidence of record shows that if the average degree of polymerization is relatively high, including, for example, 8 or 12 which is within the range of No.6,998,465, it is impossible to attain sufficient ion conductivity as well as initial discharge capacity, cycle performance and high rate discharge characteristics, as seen from Comparative Examples 1 and 2 in Table 2, as discussed previously.

Thus, as seen in the foregoing, it is respectfully submitted that the presently claimed subject matter, selecting a specific range for ℓ, m and n, p, q, r, and α, β and γ, achieves unexpectedly better results as compared with the subject matter claimed in No. 6,998,465, establishing patentability over the subject matter thereof and overcoming the obviousness-type double patenting rejection.

In Item 1 on page 2 of the Office Action mailed May 1, 2007, the Examiner contends that various claim rejections under 35 USC 102 are proper, when specific sub-ranges of various ranges in the applied documents are selected. It is respectfully submitted that such "selection" of sub-ranges shows that the

"anticipation" rejections are improper; and that, at most, a prima facie case of obviousness has been established. It is respectfully submitted that any such prima facie case of obviousness is overcome by the evidence of record, showing unexpectedly better results achieved according to the present invention.

In view of the foregoing comments and amendments, entry of the present amendments, and reconsideration and allowance of all claims presently in the application, are respectfully requested.

To the extent necessary, Applicants hereby petition for an extension of time under 37 CFR 1.136. Kindly charge any shortage of fees due in connection with the filing of this paper, including any extension of time fees, to the Deposit Account of Antonelli, Terry, Stout & Kraus, LLP, Account No. 01-2135 (case 500.42907PX1), and please credit any overpayments to such Deposit Account.

Respectfully submitted,

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